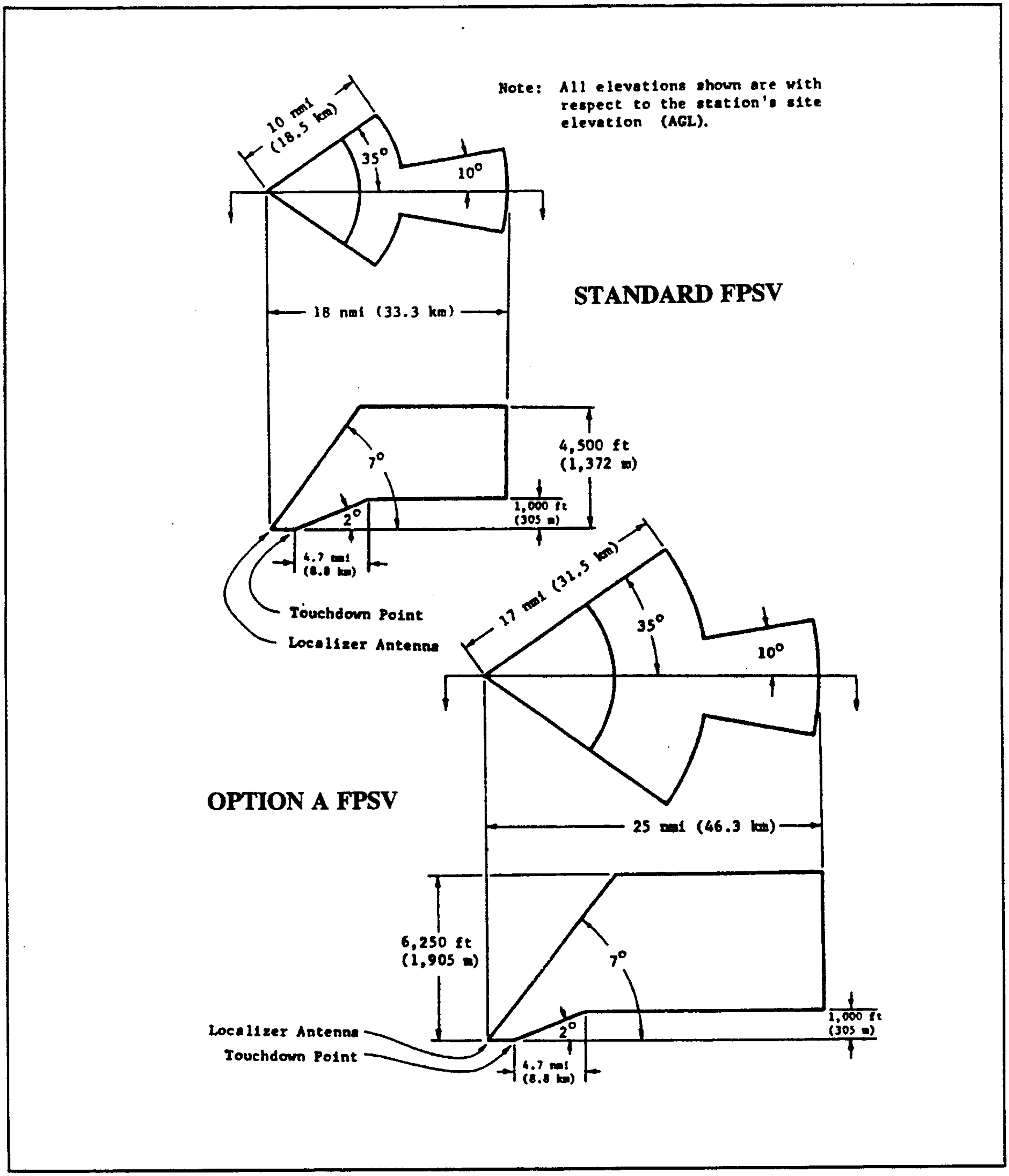
SECTION 3. ILS AND DME FREQUENCY ENGINEERING

14. FREQUENCY ENGINEERING FOR ILS AND DME.

a. ILS and DME frequencies. These frequencies and channels are listed in figure 1, section 1. The frequencies 108.10/979 MHz and 108.15/1105 MHz are specifically designated for radio navigation test generators (ramp testers) and shall not be used for operational ILS and DME facilities.

FIGURE 61. LOC FRONT COURSE FPSV'S



b. Paired frequencies. Paired frequencies as listed in figure 1 require that DME's be located on the airport near the runway for zero range indication and such that the approach path angle is less than 20 degrees for points requiring DME information.

c. FPSV's. FPSV's for the various classes of ILS/DME are shown in figures 61 through 64.

FIGURE 62. LOC BACK COURSE FPSV'S

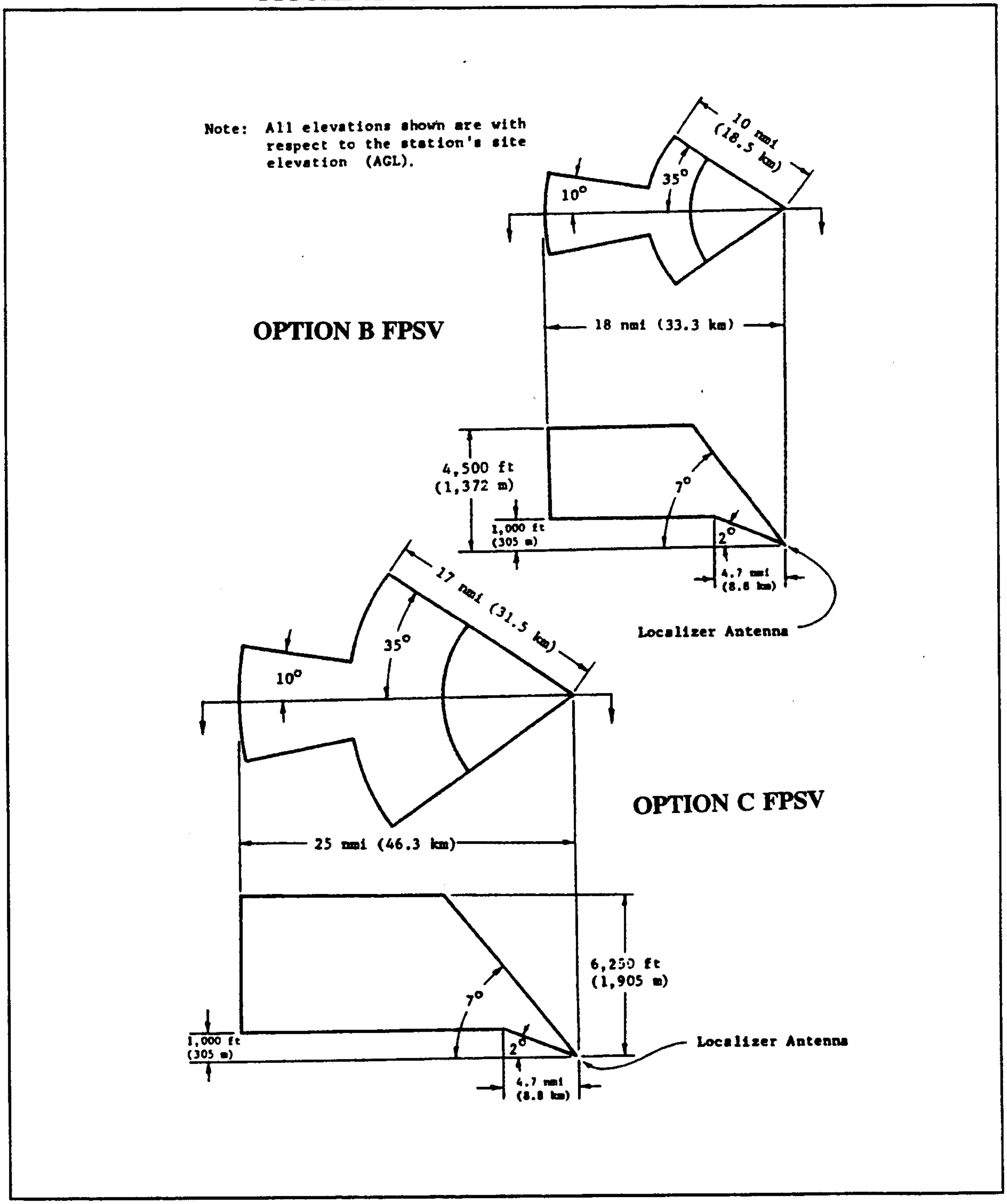


FIGURE 63. FPSV FOR ILS GS

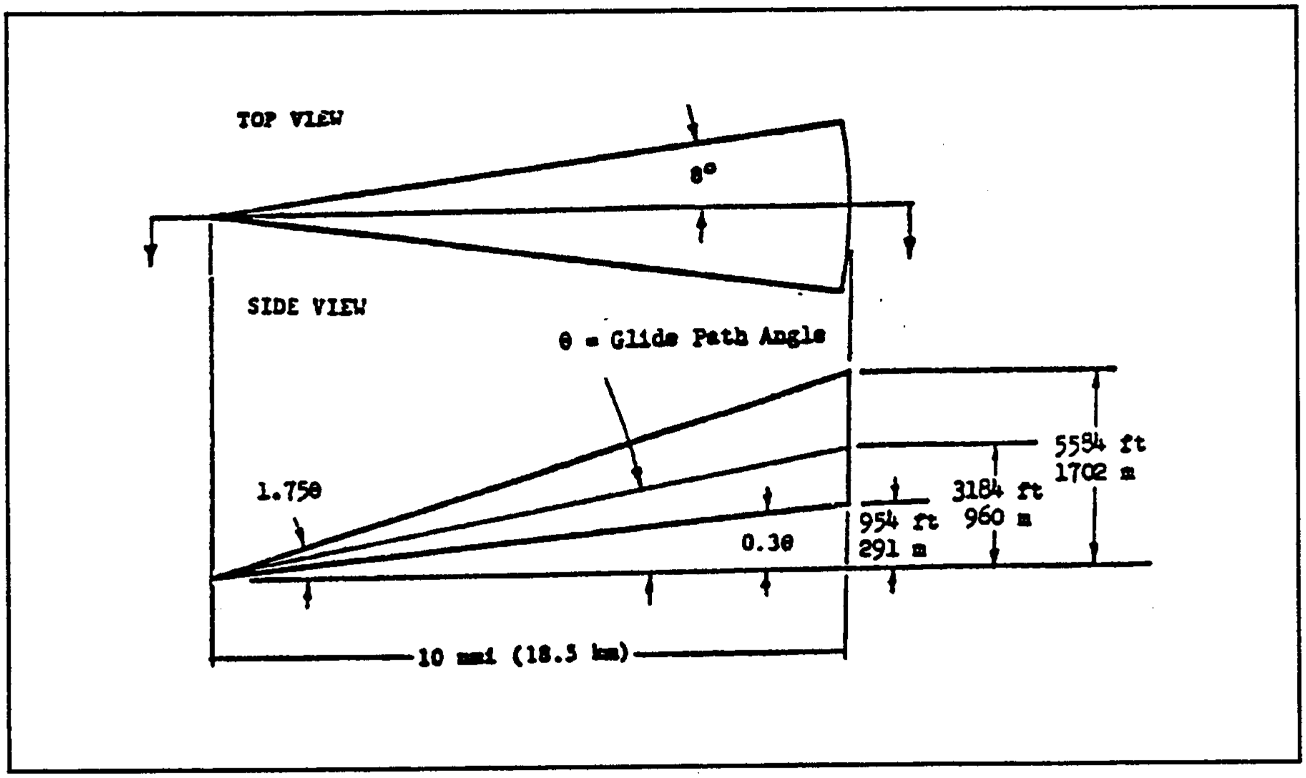
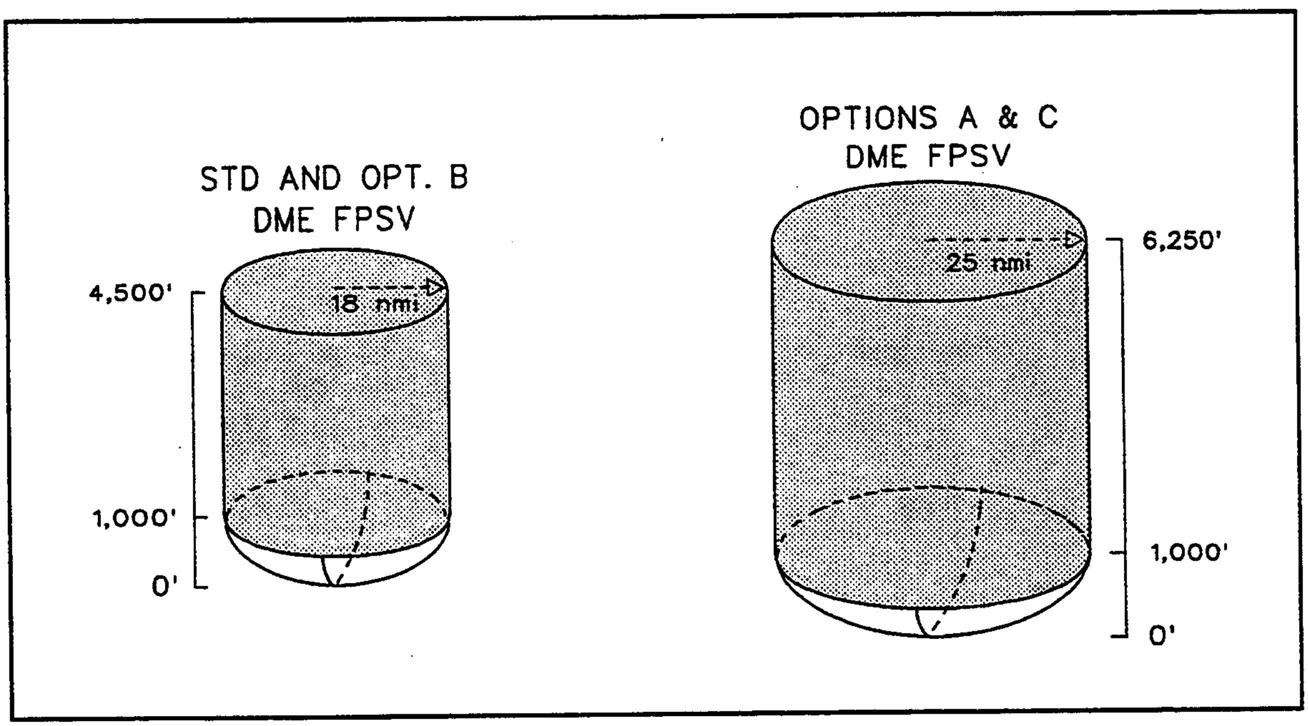


FIGURE 64. FPSV'S FOR DME'S ASSOCIATED WITH ILS



d. ILS D/U criteria. Harmful interference to ILS and associated DME facilities is avoided by geographically separating cochannel and adjacent channel assignments. Within each FPSV, the D/U ratio shall be at least the following, on a basis of 95 percent time availability. All D/U ratios include the +3 dB factor.

LOC

Cochannel	1st Adjacent Channel (±50 kHz)	2nd Adjacent Channel (±100 kHz)	3rd Adjacent Channel (±150 kHz)
+23 dB	**-4 dB Interim** **-31 dB Final**	**-43 dB**	**-47 dB**

(1) A D/U ratio of -4 dB is necessary to assure protection of 100 kHz (100 channel) navigation receivers. This -4 dB D/U ratio is referred to as the interim criterion and shall be used whenever possible to protect 100 kHz assignments.

(2) A D/U ratio of -31 dB is for 50 kHz (200 channel) navigation receivers. This is referred to as the final criterion and shall be used for 50 kHz assignments.

GS

Cochannel	1st Adjacent Channel (±150 kHz)	2nd Adjacent Channel (±300 kHz)	3rd Adjacent Channel (±450 kHz)
+23 dB	**-17 dB**	**-37 dB**	**-37 dB**

e. DME D/U criteria. Harmful interference to DME is prevented in the same manner as for ILS.

DME

Cochannel	1st Adjacent Channel (±1 MHz)	2nd Adjacent Channel (±2 MHz)
+11 dB	**-39 dB**	**-47 dB**

15. FREQUENCY ENGINEERING PROCEDURES. To ensure that the proposed ILS and DME frequencies will provide interference-free operations within their FPSV_s, the following analyses must be performed on the proposed frequencies:

a. Intersite analysis is used to determine whether the proposed frequencies meet the assignment criteria specified in paragraphs 14 d. and e. There are two analysis methods — table and calculation.

b. Cosite analysis is used to avoid interference caused by interaction between the proposed ILS and DME frequencies and other frequencies, including FM/TV in the vicinity of the proposed site. The cosite analysis procedures are discussed in the appendix.

c. Other analysis shall be performed as needed, such as correction for site elevation differences.

d. Frequency compatibility with the in-place FM Broadcast environment must be assured. See Section 4 of this appendix for use of the AAM for this function.

16. INTERSITE ANALYSIS BY THE TABLE METHOD FOR ILS LOC'S. Intersite analysis may be performed on a proposed ILS frequency pair through the use of the tables in figures 66 through 71 which show conservative-worst-case separation distances required with respect to ILS/ILS and ILS/adjacent channel VOR. In addition, the nature of the ILS LOC antenna pattern makes the cochannel and adjacent channel circumferences different. Those diagrams are shown in figure 65.

a. Figure 66 is for LOC/LOC cochannel.

b. Figure 67 is for LOC/LOC 1st adjacent channel (interim).

c. Figure 68 is for LOC/LOC 1st adjacent channel (final).

d. Figure 69 is for LOC/VOR undesired 1st adjacent. channel (interim).

e. Figure 70 is for LOC/VOR undesired 1st adjacent channel (final).

f. Figure 71 is for LOC/VOR undesired 2nd adjacent channel.

g. Site elevation differences require some compensation, for cochannel ILS LOC_s. For Standard and Option B FPSV_s, an additional 6.5 nmi must be added to r_t for each 1000_ of altitude difference. For Options A and C FPSV_s, an additional 7 nmi must be added for r_1 and 5.5 nmi for r_2, for each 1,000_. See figures 65 through 71 for r_t, r_1 and r_2 values.

h. There are no GS tables, since GS FPSV_s are protected by the geographic area covered by the FPSV of the associated LOC. However, there can be one problem which must be checked. In a few cases, LOC 1st adjacent channels are not always paired with matched GS frequencies. See channels 18X, 18Y and 38X in figure 1, section 1. The FMO must assure that a proposed "clear" LOC does not have an associated GS frequency only 150 kHz removed from an ILS at the same airport.

i. Note that RLOS is a factor. RLOS for Standard and Option B LOC FPSV is 101 nmi. RLOS for Options A and C LOC FPSV is 123 nmi.

17. INTERSITE ANALYSIS BY THE TABLE METHOD FOR ILS-DME. ILS-DME intersite analysis may be performed on a proposed DME frequency through the use of the table in figure 72 for ILS-DME cochannel which show conservative-worst-case separation distances required and figure 73 for ILS/DME with 1st adj. channel TACAN/DME undesired. Geographical separations are not required between DME and TACAN facilities separated more than 1 channel (1 MHz). There are no tables for 2nd adjacent DME/TACAN channels.

18. ILS-DME REQUIRED SEPARATION. ILS-DME facilities required separation is greater than for the frequency paired LOC facility. This is clearly evident from comparison of the LOC and DME/TACAN tables for paired frequencies. In addition, any DME associated with an ILS will have a much reduced FPSV, as indicated in figure 64, as compared to those otherwise operating.

19. USE OF THE LARGER SEPARATION REQUIREMENT. In all cases, the larger separation requirement shall be used, whether it be cochannel or adjacent channel. This requires that for each ILS frequency engineering project, a determination must be made as to whether the LOC or associated DME has the larger separation requirement.

20. ILS-ASSOCIATED DME ADJACENT CHANNEL UNDESIRED. In this case, the facilities will ordinarily be regular L-DME or T-DME of the VOR FPSV size. In these cases, the tables listed in paragraph 17 shall be used. As in all other cases, the larger requirement shall always be used whether cochannel or adjacent channel.

FIGURE 65. LOC SEPARATION DISTANCES DEFINED
(For use with figures 66-71)

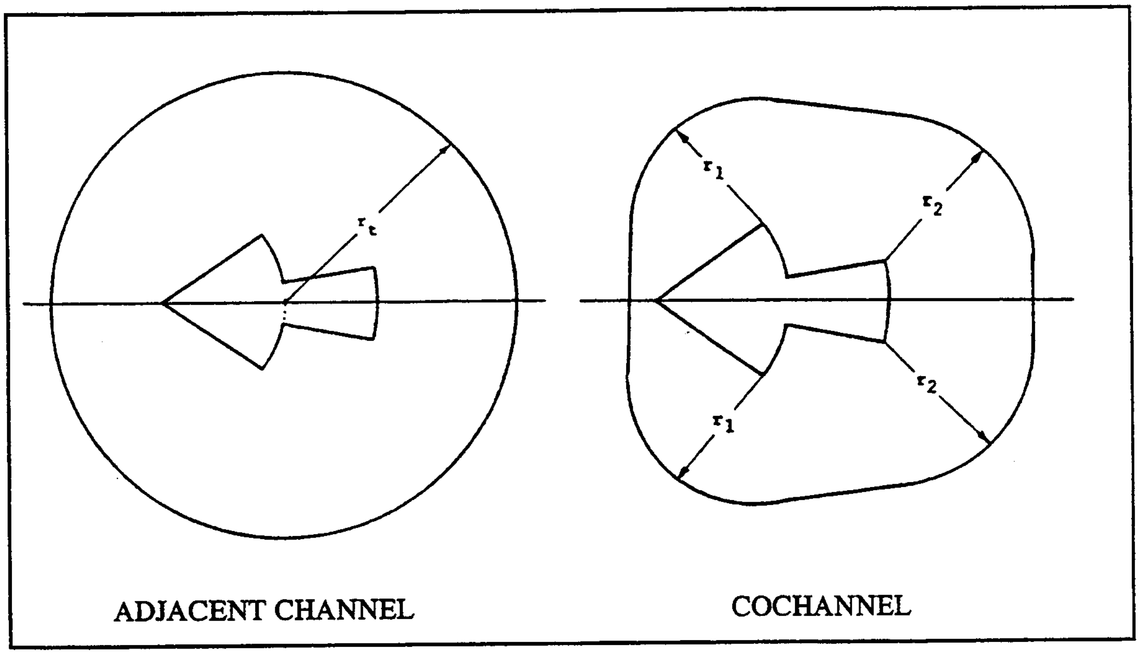


FIGURE 66. LOC/LOC COCHANNEL RADII SEPARATIONS

LOC DESIRED, LOC UNDESIRED
+23 dB PROTECTION

EIRP RATIO D/U LOC	OPTIONS A & C		STD AND OPTION B	
dB	r_1 (nmi)	r_2	r_1 (nmi)	r_2
+18	74	65	47	48
+15	83	73	53	54
+12	93	82	61	61
+9	100	92	69	69
+6	106	101	78	79
+3	110	105	85	86
±0	114	110	90	91
-3	118	115	95	96
-6	122	121	100	100
-9	#	#	100	100
-12	#	#	*	*

* = RLOS is 101 nmi for STD and Option B
\# = RLOS is 123 nmi for Options A & C

FIGURE 67. LOC/LOC 1ST ADJACENT CHANNEL - 50 kHz - SEPARATIONS -- INTERIM

LOC DESIRED, LOC UNDESIRED -4 dB PROTECTION		
EIRP RATIO D/U LOC/VOR dB	OPTIONS A & C r_t (nmi)	STANDARD & OPTION B r_t
+18	31	24
+15	34	26
+12	37	28
+9	41	30
+6	45	33
+3	52	36
±0	57	40
-3	64	44
-6	72	49
-9	80	55
-12	88	62
-15	97	68
-18	106	75

FIGURE 68. LOC/LOC 1ST ADJACENT CHANNEL - 50 kHz - SEPARATIONS -- FINAL

LOC DESIRED, LOC UNDESIRED -31 dB PROTECTION		
EIRP RATIO D/U LOC/VOR dB	OPTIONS A & C r_t (nmi)	STANDARD & OPTION B r_t
+18	17	16
+15	18	17
+12	19	18
+9	20	18
+6	22	19
+3	23	20
±0	25	21
-3	27	22
-6	29	23
-9	31	25
-12	33	27
-15	36	29
-18	39	31

FIGURE 69. LOC/VOR 1ST ADJACENT CHANNEL - 50 kHz - SEPARATIONS -- INTERIM

LOC DESIRED, VOR UNDESIRED
-4dB PROTECTION

EIRP RATIO D/U LOC/VOR dB	OPTIONS A & C r_t (nmi)	STANDARD & OPTION B r_t
+18	35	26
+15	39	28
+12	44	31
+9	49	34
+6	55	38
+3	62	42
±0	70	47
-3	80	53
-6	91	59
-9	103	67
-12	117	79
-15	#	94

= Beyond RLOS

FIGURE 70. LOC/VOR 1ST ADJACENT CHANNEL - 50 kHz - SEPARATIONS -- FINAL

LOC DESIRED, VOR UNDESIRED
-31 dB PROTECTION

EIRP RATIO D/U LOC/VOR dB	OPTIONS A & C r_t (nmi)	STANDARD & OPTION B r_t
+18	23	14
+15	24	15
+12	25	16
+9	26	17
+6	27	18
+3	28	19
±0	29	20
-3	30	22
-6	32	24
-9	35	26
-12	38	28
-15	44	31
-18	49	34

FIGURE 71. LOC/VOR 2nd ADJACENT CHANNEL - 100 kHz - SEPARATIONS

LOC DESIRED, VOR UNDESIRED
-43 dB PROTECTION

EIRP RATIO D/U LOC/VOR dB	OPTIONS A & C r_t (nmi)	STANDARD & OPTION B r_t
+18	17	11
+15	18	12
+12	19	13
+9	20	14
+6	21	15
+3	22	16
±0	23	17
-3	24	18
-6	25	19
-9	26	20
-12	28	21
-15	30	22
-18	32	23

FIGURE 72. ILS-DME COCHANNEL SEPARATIONS

ILS-DME DESIRED, ILS-DME UNDESIRED
+11 dB PROTECTION

FACIL CLASS	SEPARATION DISTANCE (nmi)
STD & OPTION B	101
OPTION A & C	123

FIGURE 73. ILS-DME 1ST ADJACENT CHANNEL SEPARATIONS

ILS-DME DESIRED, DME/TACAN UNDESIRED
-39 dB PROTECTION

FACIL CLASS	SEPARATION DISTANCE (nmi) H	L	T
STANDARD AND ALL OPTIONS	145	45	30

Note: DME's associated with ILS are all terminal functions of equal power.

21. INTERSITE ANALYSIS OF ILS BY CALCULATION METHOD. LOC antennas are highly directional, and introduce an additional factor into the ESR calculation process. That factor is the gain of the antenna system with respect to the desired facility.

a. ESR is an adjusted D/U ratio due to the differences in the carrier power and antenna gain between two stations. It is defined as follows:

$$\boxed{ESR = D/U - P_D + P_U - A_D + ASUBU + G_U - G_D}$$

Where: D/U = required D/U ratio +23 dB for cochannel LOC;
-4 dB for 1st adjacent channel LOC;
+11 dB for cochannel DME/TACAN

P_D = carrier power of the desired facility, dBW

P_U = carrier power of the undesired facility, dBW

A_D = antenna gain of the desired facility, dBi

A_U = antenna gain of the undesired facility, dBi

G_D = relative antenna gain (dB) of desired facility, at point of interest, with respect to the main beam antenna gain

G_U = same for undesired facility

b. Antenna gains (main beam and relative antenna) for individual types of LOC antennas are shown in figures 74 and 111-129.

FIGURE 74. LOC ANTENNA GAINS AND GRAPH REFERENCE

NOMENCLATURE	STYLE	MAINBEAM GAIN dB	FIGURE
MK20, FA9913	LPD (14-10) LPD (20-10)	28 28	111
FA5692, FA5693, FA5707, FA5708, FA8001, FA8002, FA8035, FA8036, FA8038, FA8621, FA8622, FA8719, FA8720, FA8843, FA8844.	V RING	12	112
FA9320	TRVLG WAVE (8 EL)	14	113
FA9325	TRVLG WAVE (14 EL)	17	114
FA9358, FA9708, FA9912 MK2, MK12.	LPD 8 EL ARRAY	17	115
FA9358, FA9708, FA9912 MK2, MK12.	LPD 14 EL ARRAY	20	116
FA9759, AN/GRN29, AN/GRN30	LPD	23	117
AN/GRN-27	TRVLG WAVE (14/6)	17	118
AN/GRN-27 (NARROW)	PARABOLIC	17	119
AN/GRN-27 (WIDE)	PARABOLIC	17	120
AN/MRN7	DIPOLE	12	121
REDLICH	LPD (14-10)	26	122
MODIFIED V RING	MOD V RING	12	123
1201	DIPOLE	16	124
1203	LPD	17	125
1204	DIPOLE	14	126
1261	DIPOLE	15	127
STAN37	DIPOLE	12	128
55	TWIN TEE	13	129
STANDARD 14 EL	V-RING	14.6	130

NOTE: LPD = Log Periodic Dipole

c. Using the calculated ESR value and appropriate facility separation curves, the required (S) can be determined. Figures 79 through 107 will be used for LOC cochannel separations; figures 108 through 110 for adjacent channel VOR_s, ILS desired; figures 111 through 130 for

ILS antenna radiation pattern charts; and figures 51 and 52 for DME/TACAN adjacent channel ESR curves.

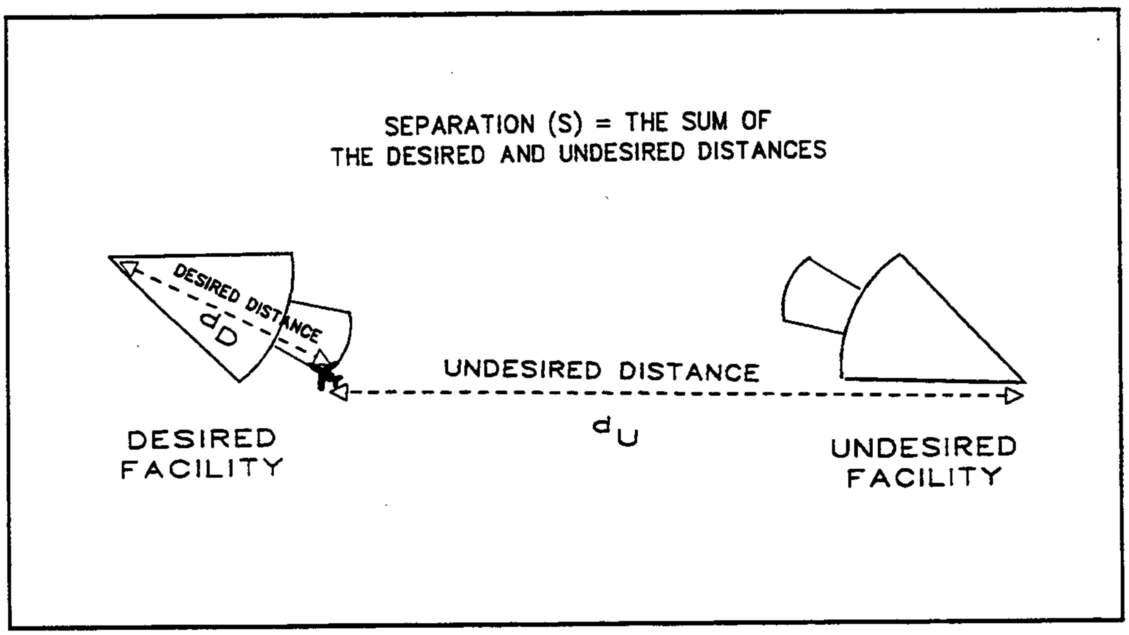
d. (S) is defined as (see figure 75):

$$\boxed{(S) = d_D + d_U}$$

Where: d_D = the distance from the desired facility to a critical point where the intersite analysis is being made.

d_U = the distance from that point to a potential interfering facility.

FIGURE 75. CRITICAL POINT SEPARATION DISTANCE



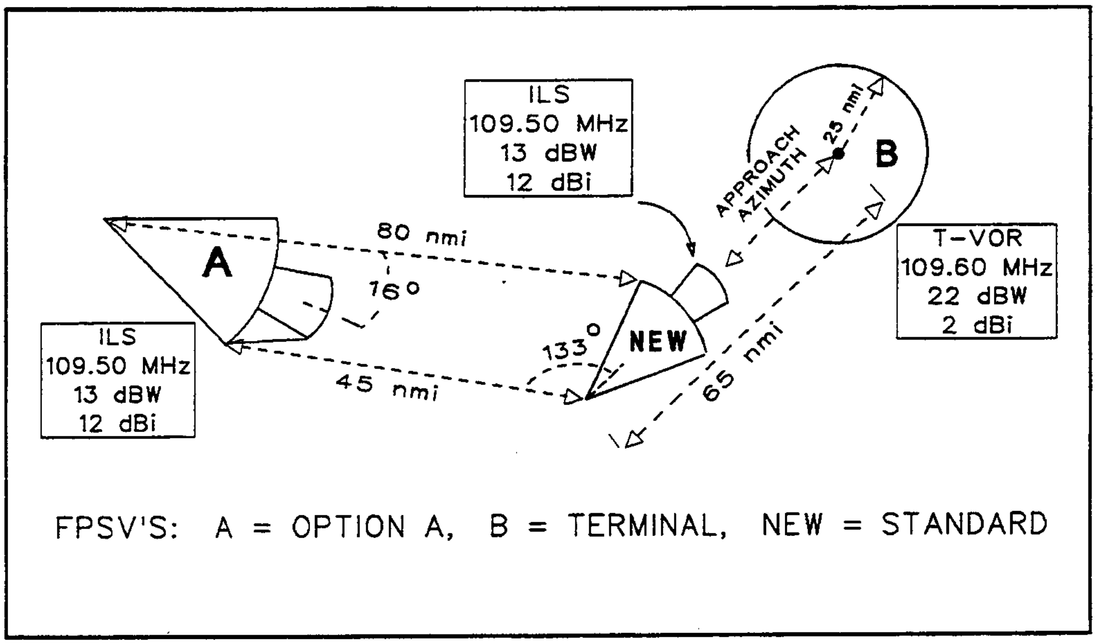
22. SPECIAL CONSIDERATION FOR ILS'S ON OPPOSITE ENDS OF A RUNWAY. In some congested areas, frequencies may not be available for a new ILS requirement. In that case, consideration must be given to putting the required ILS on the same frequency as the installed one on the opposite end of the runway. If this is necessary, the following restrictions apply:

a. ILS identification. Each ILS, which includes any COMLO_s and DME_s, if installed, must have separate and distinct identifiers.

b. Interlock requirements. Fail-safe interlock systems must be installed to prevent both ILS and any ancillary COMLO and DME from being operated simultaneously.

c. NOTAM requirement during ILS maintenance. If radiating a signal during maintenance activities is necessary, the opposite end ILS shall be NOTAMMED out of service as unusable from the Middle Marker inward. Of course, the ILS being maintained must also be NOTAMMED out of service during the maintenance period.

FIGURE 76. LOC INTERSITE ANALYSIS BY CALCULATION



23. LOC CALCULATION EXAMPLE. Refer to figure 76. The LOC facility separation, ESR, and LOC antenna patterns curves are used in these calculations. They are found in figure 36 and figures 79 through 129.

a. The facilities are: A = Option A LOC, 25 nmi @ 6250_ on 109.50 MHz, with a standard V-Ring antenna; B = T-VOR on 109.60 MHz; and N is a proposed new standard LOC, 18 nmi @ 4500_ on 109.50 MHz, also with a V-Ring antenna.

b. The proposed LOC has its main beam pointed directly at the T-VOR site. The FPSV of the T-VOR is 25 nmi at 12,000_, and as the larger FPSV, it will be checked first. N is 2nd adjacent channel to B, so D/U = -43 dB. (Para 14 d.)

$$ESR = D/U - P_D + P_U - A_D + A_U + G_U - G_D \text{ (Para 21)}$$

(1) For B as desired and N as undesired,

$$ESR = -43 - 22 + 13 - 2 + 12 + 0 - 0$$
$$= \mathbf{-42\ dB}$$

NOTE: With the nondirectional VOR antenna and the LOC pointed at 0° with respect to the VOR location, both G_U and G_D are zero. Refer to figure 35, ESR curves for ILS/VOR @ 1,000_; VOR is desired. By interpolation, a 25 nmi FPSV @ -42 dB requires a separation of (S) = 27 nmi. The example shows a distance of 65 nmi, so B is protected.

(2) For N as desired and B as undesired, with "desired" roles being reversed,

ESR = -43 - 13 + 22 - 12 + 2 + 0 - 0
= **-44 dB**

NOTE: Refer to figure 108. At 18 nmi and -44 dB, (S) = approximately 17 nmi. Since the actual separation is shown as 65 nmi, that value is >> 17, so N is protected.

(3) For N as desired and A as undesired,

ESR = 23 - 13 + 13 - 12 + 12 + (-7) - (-10)
= **+26 dB**

NOTE: N_s critical point is 16° off A_s main beam and 35° off its own main beam (see figure 112 for G_U and G_D).

(4) Refer to figure 105, ILS/ILS facility separation curves for ESR = +26 dB. By interpolation, 10 nmi @ 4,500_ yields (S) = 55 nmi. At the critical point on N, an aircraft will be 10 nmi from N and 80 NM from A; 80 + 10 = 90 nmi. The value 90 > 55, so N will be protected.

(5) For A as Desired, and N as Undesired,

ESR = 23 - 13 + 13 - 12 + 12 + (-20) -(-5)
= 23 - 0 - 15 = **+8 dB**

NOTE: A_s critical point is 133° off N_s main beam and 10° off its own main beam (fig 112).

(6) Refer to figure 99. For 25 nmi @ 6,250_, interpolation will show (S) = 67 nmi. A_s 25 nmi FPSV plus the 45 nmi separation = 70 nmi. The value 70 > 67; A is protected.

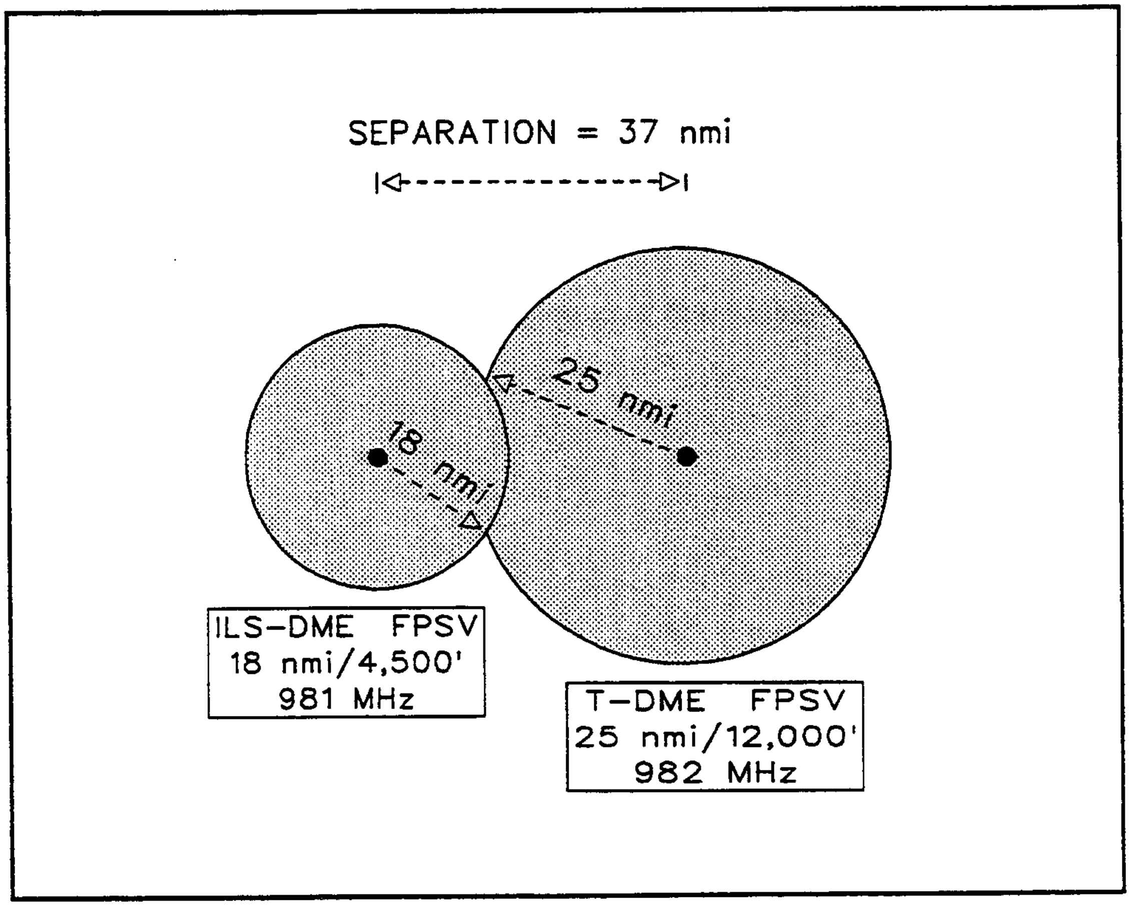
(7) All four conditions of cochannel and adjacent channel are satisfied. Unless there is an adjacent channel GS frequency problem (see paragraph 16h), the proposed assignment could be considered safe.

(8) However, the assignment may not be made until the paired DME channel is checked.

FIGURE 77. DME AND TACAN ANTENNA GAIN FIGURES

	TYPE	GAIN (dB)
	CA3167 (Discone)	11
	FA8974 "	11
D	FA9639 "	11
M	FA9783 "	11
E	MK3 "	9
	596B "	9
	1020 "	9
	5351A (Dipole)	10
	5960	8
	FA 10153	8
	DB-510A	8
	1118 (ASII)	8
T	FA6239 (TRA-2)	7
A	FA6339 (MOD. TRA-2)	9
C	YNI103A or YNI104A	6
A	AN/GRN9	9
N	GRA047 (Dipole)	6

FIGURE 78. ADJACENT CHANNEL ILS-DME/T-DME SEPARATION



24. DME INTERSITE ANALYSIS BY THE CALCULATION METHOD. Intersite analysis must now be performed. A check of figure 72 will show that the situation shown in the paragraph 23 and figure 76 example would prevent the ILS assignment. That is because the DME_s associated with the A and N LOC_s are only about 67 nmi apart, whereas 125 nmi separation is required.

a. DME/TACAN facility separation curves are found in figures 44-50; ESR ratio curves, in figures 51 and 52.

b. Refer to figure 78. The ESR is calculated as follows. If both facilities have the same power and same antenna gains, the ESR formula reverts to just the D/U value for the adjacent channel. For the ILS-DME, it is -20 dB and for the T-DME it is -26 dB (see paragraph 14e). Note that the "G" factors do not apply here, since both antennas are nondirectional.

c. Refer to figure 51. For an ILS-DME @ -20 dB and 18 nmi, S = 25 nmi. For a T-DME @ -26 dB and 25 nmi, S = 28 nmi. The example in figure 78 shows 37 nmi, so both facilities are protected.

25. ILS MARKERS. Markers are continuously operating low power transmitters, with antennas radiating signals in an upward direction in a fan shape. They are to indicate to the pilot flying a course that the aircraft has passed over a particular point on the ground below.

a. Markers are located at specified distances from the touchdown point on a runway, and are called "Inner", "Middle", "Outer" and "Back Course" markers (IM, MM, OM and BCM).

b. Each Marker has its own distinctive type identification. The exact identification is:

(1) OM: — — — — — (continuous dashes @ 400 Hz)

(2) MM: × — × — × — (alternating dots and dashes @ 1300 Hz)

(3) IM: × × × × × × (continuous dots @ 3000 Hz)

(4) BCM: × × × × × × (alternating pairs of dots @ 3000 Hz)

c. Marker frequency is 75.000 MHz. It is used for all markers, world-wide. Protection between adjacent area Markers is provided by the narrow upward antenna radiation pattern. Power and pattern are determined by Flight Inspection at the time of commissioning of the facility. Normally, the FMO is not required to do any frequency engineering. Occasionally, parallel runways close together may be have the markers tuned offset in frequency to prevent RFI between the sites.

26. thru 30. RESERVED.